# SOME EXPERIMENTS WITH A BORIC-ACID CANNING POWDER



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# SOME EXPERIMENTS WITH A BORIC-ACID CANNING POWDER.

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## CANNING POWDER EXAMINED.

Among the many inquiries concerning canning problems received by the microbiological laboratory of the Bureau of Chemistry, information as to the use of "canning powder" to supplement heat in processing has been frequently sought. These requests come from places widely enough separated to indicate that propaganda for the introduction of some sort of antiseptic in the home preservation of food is fairly widespread.

Specific inquiries supplemented by samples obtained for analysis indicated the use of a particular preparation in many sections of the country. Several series of packages of this preparation, therefore, were secured for study. Each package consisted of an envelope of white powder bearing printed directions for use. To furnish a basis for intelligent work one series of packages was analyzed.[1] The powder consisted of approximately 95 per cent of boric acid and 5 per cent of common salt, the actual divergences from this average being about one-half per cent in either direction. The net weight of 36 envelopes averaged 28.97 grams, with a minimum of 25.22 and a maximum of 34.89 grams. Evidently each package was intended to contain 1 ounce (28.34 grams) of powder. At the minimum content found, however, the loss of antiseptic power might be great, while at the maximum content the excess of toxicity might be serious.

The directions given on the envelopes of powder called for the use of one-fourth package (one-fourth ounce) to each quart of finished material, and provided a means for the rough division of the powder into fourths. No suggestion that the use of an excess of the canning powder might be harmful was offered. Considering the difficulty of

[1] The chemical work was done by J. I. Palmore, of the food control laboratory of the Bureau of Chemistry.

estimating how much bulky fresh material would make a quart of finished or canned material, together with the haphazard method of measuring the powder and the wide range of variation found in the contents of the packages, the quantity of the canning powder actually used in successive lots of food would be variable enough to lower its antiseptic value, or, possibly, if in excess, to affect the consumer.

## ANTISEPTIC VALUE OF POWDER.

### TEST-TUBE EXPERIMENTS.

To obtain some measure of the antiseptic value of the powder at the minimum, average, and maximum concentrations, as indicated by the actual content of the packages, standard culture media were made containing the canning powder in such quantities as to make a concentration of 0.63, 0.724, and 0.872 per cent (one-fourth package per quart), respectively. These were inoculated, together with controls on the same media without the powder, with cultures of various bacteria and a yeast. Daily observations of the cultures were made for a period of one week. The organisms chosen (Table 1) represent certain large groups commonly found in contaminated or spoiled products and are significant in considering the soundness or safety of food supplies.

Table 1.—*Bacteria and yeast used for inoculations.*

| Organism. | Source. |
|---|---|
| *Bacterium aerogenes* | Italy. |
| *Bacterium coli* | Fecal strain from ripe olives. |
| *Bacterium enteritidis* | Jordan. |
| *Bacterium paratyphosum* A | Mears. |
| *Bacterium paratyphosum* B | Rowland. |
| *Bacterium typhosum* | Mears. |
| *Bacterium suipestifer* | Krumwiede. |
| *Proteus vulgaris* | Rettger. |
| *Staphylococcus aureus* | Rettger. |
| *Streptococcus lacticus* | Ayers. |
| *Streptococcus pyogenes* | Rettger. |
| *Bacillus mesentericus* ruber | Le Fevre. |
| *Bacillus mesentericus* niger | Le Fevre. |
| *Bacillus subtilis* | Le Fevre. |
| *Bacillus botulinus* Type A | Boise strain. |
| *Bacillus botulinus* Type A | Memphis strain. |
| *Bacillus botulinus* Type B | "District" strain. |
| *Bacillus sporogenes* | Savage. |
| *Bacillus sporogenes* | Mullet strain. |
| *Bacillus putrificus* | Rettger. |
| *Bacillus stearothermophilus* | Donk. |
| *Bacillus bulgaricus* | Sherman. |
| *Bacillus acidophilus* | Rettger. |
| K 5 (bacillus from pickle brine) | Le Fevre. |
| Pink yeast | Hunter. |

At the minimum concentration (0.63 per cent) the canning powder exhibited a selective antiseptic action on the growth of these organisms. Of the 25 organisms tested the powder prevented the growth of but three (the yeast, *Proteus vulgaris*, and *B. stearothermophilus*). All but one (*B. stearothermophilus*) of these three are aerobic and non-spore-forming and would be killed in any ordinary process of canning. The behavior of *B. bulgaricus*, *B. acidophilus*, and the pickle bacillus is interesting. Their growth was prompt, while that of *Streptococcus lacticus* was inhibited until the fourth day. The growth of the remaining organisms was but slightly less abundant on this medium than on the control. It is significant that not only was the growth of none of the resistant anaerobic spore-forming bacteria stopped by the powder, but in the medium containing the powder it was as luxuriant as in the control medium. The toxin-producing power of *B. botulinus* makes this especially important.

With the average concentration of the canning powder (0.724 per cent) the results were similar to those obtained with the minimum concentration, in that the growth of certain of the aerobic organisms (*B. mesentericus* niger, *Bact. aerogenes*, *Bact. typhosum*, *Bact. paratyphosum* A and B, *Staphylococcus aureus*, *Streptococcus lacticus*, the yeast, and *B. acidophilus*) was slightly inhibited and that of a few (*B. subtilis*, *Proteus vulgaris*, *Bact. coli*, *B. stearothermophilus*, *Bact. enteritidis*, and *Bact. suipestifer*) was entirely prevented. The resistant anaerobic species, however, were not affected, even to the extent of having their growth noticeably checked.

Practically the same results were obtained at the maximum concentration (0.872 per cent), except that more of the aerobic organisms (*B. mesentericus* niger, *B. subtilis*, *B. stearothermophilus*, *B. acidophilus*, *Bact. typhosum*, *Proteus vulgaris*, and the yeast) were checked and those that were not (*B. mesentericus* ruber, *Bact. aerogenes*, *Bact. coli*, *Bact. enteritidis*, *Bact. suipestifer*, *Bact. paratyphosum* A and B, *Streptococcus pyogenes*, *Streptococcus lacticus*, *Staphylococcus aureus*, *B. bulgaricus*, and the pickle organism) grew more slowly than at the lower concentrations. As before, the anaerobic species were not affected by the presence of the canning powder.

Fifteen cultures (*B. mesentericus* niger, *B. mesentericus* ruber, *B. subtilis*, *Bact. aerogenes*, *Streptococcus pyogenes*, *Proteus vulgaris*, *Bact. typhosum*, *Bact. coli*, the yeast, *B. stearothermophilus*, 2 strains of *B. sporogenes*, and 3 strains of *B. botulinus*) were tested with three times (2.172 per cent) the average concentration (0.724 per cent) of canning powder recommended, with the result that the growth of all but two (*B. mesentericus* ruber and *Bact. aerogenes*) of

the organisms was prevented, and the growth of these two was meager and slow.

Since the growth of *B. botulinus* was not inhibited in the foregoing experiments by the minimum, average, or maximum concentration of the canning powder, a standard medium containing the powder in concentrations varying from 0.8 to 2 per cent was made. and a number of strains of *B. botulinus* (Laboratory Nos. 619, 621, 622, 623, 626, and 629, respectively) and *B. sporogenes* (Savage and Mullett) were grown in it. Daily observations were made as before for a period of two weeks. None of the *B. botulinus* strains were prevented from growing by even 1 per cent of the canning powder. One strain (619) grew slowly at that concentration, but growth was clearly evident on the ninth day after inoculation. Two strains (623 and 626), which grew in the presence of 1.5 per cent of the powder, did not begin to grow until the fourth day. The *B. sporogenes* strains grew well at this concentration. A concentration of 2 per cent, however, restrained all the *B. botulinus* strains, as well as the *B. sporogenes* strains. Although these concentrations are much higher than those advocated for use in actual canning, the results obtained with them are significant in that *any sense of safety from food poisoning founded on the use of the antiseptic is groundless, and dependence on it becomes a source of danger.*

A similar series of cultures was made to test the effect of canning powder upon a group of molds. Tubes of dextrose agar to which the canning powder had been added in percentages of 0.63, 0.724, and 0.87 were prepared and inoculated, together with controls on the same medium without canning powder.

For this purpose the following molds were used: *Penicillium brevicaule*, *P. camemberti*, *P. roqueforti*, *P. divaricatum*, *P. spinulosum*, *P. viridicatum*, *P. oxalicum*, *P. expansum*, *Aspergillus flavus*, *A. niger* (2 strains), *A. oryzæ*, *A. fumigatus*, *A. terreus*, *A. nidulans*, *A. sydowi*, *A. repens*, *Acrostalagmus cinnabarinus*, *Cephalothecium roseum*, *Trichoderma lignorum* (?), one species of Rhizopus, Dematium, and Syncephalastrum sp., and three strains of Cladosporium.

Observations were made at the end of 3, 6, 11, and 17 days. The control cultures showed the usual colonies characteristic of each species. Twelve of these strains showed growth, but every one of them was delayed in development by the canning powder. Of these, *Aspergillus niger*, *A. terreus*, *Penicillium camemberti*, and Dematium eventually produced colonies characteristic of the species. *Penicillium spinulosum*, representing the Citromyces section of the group, *P. expansum* (the apple rot), *P. divaricatum*, two strains of Cladosporium, and *A. sydowi* showed more or less growth without producing the typical coloring characters within the time of observation.

The Acrostalagmus barely showed germination in the lowest concentration of powder. The other organisms failed to germinate in this experiment. In food canning experiments with the powder, however, an occasional mold colony was encountered and transferred to culture media. In this way *Penicillium roqueforti* (roquefort cheese mold) was once obtained in a cherry, *Aspergillus fumigatus* from tomatoes, *A. flavus* from peas, and one mucor from peaches. No one of these four species grew in the test-tube series of cultures, but *A. flavus* and *A. fumigatus* grew slowly in another culture experiment in the presence of 0.7 per cent of the powder. Clearly, then, the boric-acid canning powder in question has a selective effect on molds also, both in reducing the number of species which will germinate and in delaying or restricting the development of others, but it will not entirely eliminate spoilage due to certain common species of mold.

## PRACTICAL CANNING EXPERIMENTS.

To test the efficiency of the canning powder under practical conditions, many of the fruits and vegetables in season were canned with it according to the directions printed on the packages of the powder and given in accompanying literature. To check the efficiency of the method of canning recommended, similar materials were canned in the same way, omitting the powder, and also by a well-known method. Wherever feasible three such series of samples for each product were prepared as follows:

Series 1: Prepared with the canning powder in accordance with directions.

Series 2: Prepared as in Series 1, but *without the canning powder.*

Series 3: Prepared by the so-called "one-period cold-pack" method (Farmers' Bulletin 829).

The method used in Series 1 varies slightly for the different vegetables and fruits, but is essentially that of cooking in the open kettle, with the addition of the canning powder at a particular stage in the cooking. The point at which the powder is added varies with the product and, with the exception of rhubarb, mincemeat, relishes, and pickles, is followed by a period of subsequent cooking so as to take a reasonable advantage of whatever efficiency the boric acid has as a sterilizing agent.

The products canned[2] were asparagus, cherries, corn, cucumber salad, lima beans, mincemeat, peaches, pears, peas, rhubarb, strawberries, string beans, and tomatoes. Materials were obtained in as fresh a condition as possible from the Washington City Market and were canned as soon as practicable after delivery. Pint glass jars

[2] The canning was done by Mrs. Mabel Heffner of the States Relations Service, U. S. Department of Agriculture.

were used as containers. Rubbers were tested before use, and the sealed jars were examined carefully for leaks before the products were stored in the basement of the Bureau of Chemistry.

A number of jars in each series were artificially inoculated with bacteria at the time of canning. The bacteria used were *B. coli*, *B. aerogenes*, *B. subtilis*, *B. stearothermophilus*, *Proteus vulgaris*, *B. botulinus*, and *B. sporogenes*. Several strains of the last two species were used. In all, 310 pints of material were canned. Of these 175 were inoculated. Of the 310 pints canned, 174 were put up with the canning powder (Series 1), and of these 98 were inoculated; 46 were canned as in Series 1, but without the powder (Series 2), and 21 of them were inoculated; 90 were canned by the one-period cold-pack method (Series 3), and 56 of them were inoculated.

After being stored for from 1 to 3 months some of the jars of each product in each series were opened and examined physically and bacteriologically for signs of spoilage. A detailed record of the condition of each jar was kept. This included the condition of the jar and its contents, the H-ion concentration (colorimetric method of Clark and Lubs[3]), the types of bacteria present in the juice of the material (as determined by Gram stained smears), and the types of bacteria found in aerobic and anaerobic cultures made from the material. In all, 177 jars were thus examined. The remaining jars that were not opened were examined frequently for physical evidences of spoilage, such as gas production, foul odor, and disintegration of material. The correlation between these findings and the bacteriological results was so close that for practical purposes the material could be judged as spoiled or not merely by a physical examination of the jar.

The results of the bacteriological examinations are summarized in Table 2. The word "spoiled" is applied to those jars in which there was an active growth of anaerobic bacteria. Where organisms were recovered in cultures from either uninoculated or inoculated jars in which there was no evidence of the growth of the bacteria the material was not considered to have spoiled.

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[3] Clark, W. M., and Lubs, Herbert A. The Colorimetric Determination of Hydrogen Ion Concentration and Its Application in Bacteriology. J. Bact., 2 (1917): 1–34, 109–136, 191–236.

TABLE 2.—*Summary of canning experiments.*

| Product canned. | Series 1 (with canning powder). | | | | | |
|---|---|---|---|---|---|---|
| | Number canned. | Number inocu-lated. | Number examined bacteriologically. | | Number spoiled. | |
| | | | Check. | Inocu-lated. | Check. | Inocu-lated. |
| Asparagus | 24 | 16 | 6 | 10 | 6 | 10 |
| Cherries | 12 | 6 | 2 | 4 | | |
| Corn | 12 | 9 | 1 | 5 | 1 | 5 |
| Cucumber salad | 4 | 2 | 1 | | | |
| Lima beans | 8 | 6 | 1 | 3 | 1 | 3 |
| Mincemeat | 4 | 2 | 1 | 1 | 1 | 1 |
| Peaches | 8 | 5 | 2 | 4 | | |
| Pears | 8 | 5 | 2 | 3 | | |
| Peas | 14 | 8 | 2 | 4 | 2 | 4 |
| Rhubarb | 24 | 12 | 8 | 7 | | 1 |
| Strawberries | 24 | 12 | 9 | 7 | | [a] 1 |
| String beans | 20 | 7 | 8 | 4 | 5 | 4 |
| Tomatoes | 12 | 8 | 2 | 5 | | 4 |
| Total | 174 | 98 | 45 | 57 | 16 | 33 |

| Product canned. | Series 2 (without canning powder). | | | | | |
|---|---|---|---|---|---|---|
| | Number canned. | Number inocu-lated. | Number examined bacteriologically. | | Number spoiled. | |
| | | | Check. | Inocu-lated. | Check. | Inocu-lated. |
| Asparagus | | | | | | |
| Cherries | 3 | 1 | 2 | | | |
| Corn | 2 | 1 | 1 | 1 | 1 | 1 |
| Cucumber salad | 4 | 2 | 1 | 1 | | |
| Lima beans | 4 | 3 | | 3 | | 3 |
| Mincemeat | 2 | | 1 | | | |
| Peaches | 2 | 1 | | 1 | | |
| Pears | | | | | | |
| Peas | | | | | | |
| Rhubarb | 6 | 4 | 1 | 3 | | |
| Strawberries | 6 | 3 | 1 | 2 | | |
| String beans | 11 | 2 | 6 | 2 | 6 | 2 |
| Tomatoes | 6 | 4 | 1 | 2 | 1 | 2 |
| Total | 46 | 21 | 14 | 15 | 8 | 8 |

| Product canned. | Series 3 (one-period cold-pack method). | | | | | |
|---|---|---|---|---|---|---|
| | Number canned. | Number inocu-lated. | Number examined bacteriologically. | | Number spoiled. | |
| | | | Check. | Inocu-lated. | Check. | Inocu-lated. |
| Asparagus | 14 | 6 | 4 | 4 | | |
| Cherries | 8 | 4 | 2 | 2 | | |
| Corn | 10 | 6 | 2 | 2 | 1 | 2 |
| Cucumber salad | | | | | | |
| Lima beans | 8 | 6 | 1 | 4 | | 4 |
| Mincemeat | | | | | | |
| Peaches | 6 | 4 | 1 | 2 | | |
| Pears | 6 | 4 | 1 | 2 | | |
| Peas | 10 | 8 | 2 | 4 | 2 | 3 |
| Rhubarb | 8 | 6 | | 3 | | |
| Strawberries | 4 | 2 | 1 | 1 | | |
| String beans | 8 | 4 | 2 | 2 | 1 | 1 |
| Tomatoes | 8 | 6 | 1 | 3 | | 1 |
| Total | 90 | 56 | 17 | 29 | 4 | 11 |

[a] The inoculum (*B. sporogenes*) was added after cooking the product.

Grouping the products canned, the following conclusions may be drawn from Table 2: None of the fruits canned by the "open-kettle" method, with or without the canning powder, or by the "one-period cold-pack" method spoiled, with the exception of an inoculated jar of strawberries and a few jars of other fruits, in which small mold colonies were found. In the case of the strawberries, the inoculum, *B. sporogenes*, was added just before the jar was sealed and the product received no subsequent processing. Acid products (Table 3) are usually considered to be easily preserved. The keeping of the majority of those canned in these experiments, therefore, is but the ordinary experience.

On the other hand, the more or less neutral products (Table 3) are generally accepted as being more difficult to can successfully. In one series a total of 78 cans of corn, asparagus, peas, string beans, and lima beans were packed with the canning powder, using products from the city market. As determined by physical examination, 68 of the total number spoiled. Forty-four of the 78 cans put up were examined bacteriologically, with the result that 41 showed bacterial activity. In another series of 50 cans put up by the so-called "cold-pack" method, 14 spoiled. Neither of the methods used, therefore, proved adequate to preserve these particular lots of vegetables purchased in the city wholesale market. It is evident also that the boric acid of the canning powder failed to overcome either the natural infection or the inoculation added in the laboratory.

Of the other products studied, tomatoes put up with the canning powder but not inoculated remained sound, whereas 4 out of 8 cans inoculated spoiled. The tomatoes which received the same cooking but no powder spoiled. This gives in the case of tomatoes some support to the claim that the addition of the canning powder will permit a shortening of the cooking process. Thirty of the jars of rhubarb were packed in water without cooking, according to the method recommended. Of these 24 contained canning powder, 12 of which were inoculated, while 6 were in cold water only. Of these 30 jars packed without cooking one inoculated with *B. sporogenes* spoiled; the remaining 29, with and without the canning powder, showed no bacterial activity. This result may be fairly attributed to the natural acidity of the rhubarb rather than to the powder. Similarly, in the cucumber salad and mincemeat the presence of a large quantity of vinegar accounts for the absence of spoilage.

*Bacillus botulinus* did not grow in any of the fruits canned, but it did grow and produce its toxin in most of the vegetables canned. Samples of asparagus from Series 1 (with canning powder) and Series 2 (without canning powder), which had been inoculated with *B. botulinus* and which showed extensive spoilage on opening, produced typical symptoms of botulism and death in guinea pigs fed

with 5 cubic centimeter amounts of the juice. There was no growth of the organism in asparagus canned by the cold-pack method. *B. botulinus* grew and produced toxin in corn, lima beans, and string beans, put up in all three series. The spoilage in these products was particularly offensive. Large quantities of gas were formed, the liquid spurted when the jars were opened, and the material was more or less disintegrated. Peas canned with the canning powder and inoculated with *B. botulinus* proved toxic to guinea pigs, while those canned by the cold-pack method were not toxic. *Bacillus botulinus* did not grow in the rhubarb, mincemeat, or cucumber salad canned. It did grow in tomatoes canned without the canning powder (Series 2) and by the cold-pack (Series 3) method, but not in tomatoes canned with the canning powder. The tomatoes were slightly overripe when canned, and the addition of the boric-acid canning powder in Series 1 evidently protected them.

These results with *B. botulinus* in the canning of the so-called neutral products, which are in harmony with the results in the test-tube experiments, show that the boric-acid canning powder is not a safeguard from the type of food poisoning known as botulism or from extensive spoilage by *B. sporogenes*. *Bacillus sporogenes* is a common organism, and, according to Burke[4] and Meyer,[5] *B. botulinus* is more abundant than has heretofore been believed. This makes it all the more imperative that methods of canning shall be such as to eliminate, as far as possible, spoilage by these organisms, especially that of the toxin-producing *B. botulinus*.

## DISCUSSION OF RESULTS.

The use of canning powder is further complicated by the physiological factor of taste. Those who have condoned the use of such powder in canning have put forth the argument that the small amount of antiseptic present in a quart of food is no more harmful than the use of the common condiments which are also poisonous in quantity. They have failed to emphasize the fact that condiments by their taste alone give ample warning to the consumer long before a poisonous concentration is reached. There was practically no indication, however, of the presence of boric-acid canning powder in the foods canned in the bureau. Various members of the microbiological laboratory tasted product after product. They were aware, of course, that some contained the powder and so were more critical than they might have been otherwise. Even for them it required close attention to detect the presence of the powder in any of the

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[4] Burke, G. S. The Occurrence of *Bacillus Botulinus* in Nature. J. Bact., 4 (1919): 541–553.

[5] Meyer, K. F., and Geiger, J. C. The Distribution of the Spores of *B. Botulinus* in Nature. Public Health Reports, 36 (1921): 4.

samples. The consumer has no protection against the use of an excess of the powder except the slight change in acidity, which becomes evident only when the excess is marked. There is, therefore, no comparison to be made between condiments and the boric-acid canning powder in this respect.

These experiments contribute little toward the controversy as to the effect of boric acid upon the consumer, although, in collaboration with the Bureau of Animal Industry, products canned with the boric-acid canning powder were shown to be deleterious to chickens (reported elsewhere).

No claim of food or condimental value has ever been made for boric acid. Antiseptic power and harmlessness in the amounts used are its sole claims to a place in any food product. Analyzed on the basis of these experiments, the antiseptic power of boric acid has not proved great. What antiseptic power it has may be due either to its influence upon acidity or to the selective effects of the boron compound upon microorganisms. Kühl,[6] Tanner and Funk,[7] Lazarus,[8] and others have also reported feeble antiseptic powers for boric acid.

To determine the relation of the canning powder to acidity the hydrogen ion concentration of the media used, both with and without the powder, was determined by the colorimetric method. In the test-tube experiments the dextrose agar had a pH value of 7 without the canning powder and of 6.5 with the canning powder. Milk had a pH value of 6.5 before the addition of the powder and of 6 afterwards. The pH value of wort broth was 5 without the powder and 4.5 with it. The acidities of the fruits and vegetables used in the canning experiments are shown in Table 3.

TABLE 3.—pH *values* [a] *of products canned.*

| Product. | Series 1 (method recommended, using canning powder). | Series 2 (method recommended, omitting canning powder). | Series 3 (cold-pack method). | Product. | Series 1 (method recommended, using canning powder). | Series 2 (method recommended, omitting canning powder). | Series 3 (cold-pack method). |
|---|---|---|---|---|---|---|---|
| Cherries | 4.0 | 4.5 | 4.5 | Peas | 5.0-5.5 | ([b]) | 6.0-6.5 |
| Peaches | 3.5 | 4.0 | 5.0 | Rhubarb | 3.5-4.0 | 4.0 | 4.0 |
| Pears | 3.5 | ([b]) | 4.5 | String beans | 5.0 | 5.5 | 6.5 |
| Strawberries | 4.0 | 4.5 | 4.5 | Tomatoes | 4.5 | 5.5 | 5.0 |
| Asparagus | 5.0-5.5 | 6.0-6.5 | 6.0 | Cucumber salad | 3.5 | 4.0 | ([b]) |
| Corn | 5.5 | 6.0 | 6.5 | Mincemeat | 3.5 | 4.0 | ([b]) |
| Lima beans | 6.5 | 7.0 | 6.5-7.0 | | | | |

[a] Determined for uninoculated jars at time of bacteriological examination.

[b] None canned.

[6] Kühl, H. Boric Acid as a Preservative. Pharm. Centr., 50 (1909): 559–561.

[7] Tanner, F. W., and Funk, R. S. Some Observations on the Use of Boric Acid as a Disinfectant. Am. J. Pharm., 91 (1919): 206–210.

[8] Lazarus, A. Die Wirkungsweise der gebrauchlicheren Mittel zur Conservirung der Milch. Zts. Hyg., 8 (1890): 207–239.

From these figures it is evident that the boric-acid canning powder in the amounts prescribed produces a slight but measurable increase in acidity. Bigelow and Cathcart,[9] Weiss,[10] and others have tested the relation of acidity as measured in this way to the effectiveness of processing temperatures. Increase in acidity has been shown to be a factor in bacterial destruction great enough to assist materially in sterilizing. The experiments reported here, however, indicate with equal clearness that the cooking prescribed for use with the powder was still inadequate to produce any large percentage of sterility product by product.

In the cultural tests the canning powder introduced in the medium did restrain to a certain extent the yeast, certain molds, the non-spore-forming and some of the spore-forming aerobic bacteria. Since the molds and non-spore-forming bacteria, however, do not survive any standard cooking process, they appear in canned products only when totally inadequate processing periods and temperatures are used. In the authors' canning experiments these and the aerobic spore-forming bacteria do not appear as factors in loss. On the other hand, the spore-forming anaerobic organisms grew equally well in the presence of the canning powder in the test-tube and in the practical canning experiments. Manifestly neither the selective toxicity of the boron compound nor the increase in acidity as an aid in sterilization was adequate to prevent the loss. The group of organisms selected in these experiments included a series of strains of *B. sporogenes*, obtained in cases of extensive loss of canned food, and of *B. botulinus*, obtained from canned food responsible for food poisoning. The canning powder as used is seen, therefore, to fail entirely to protect the product against these two groups of organisms, which represent the most dangerous phase of spoilage in canned food.

## SUMMARY.

The boric-acid canning powder in the amount recommended exerted a selective antiseptic action toward certain molds and members of the aerobic group of microorganisms in test-tube experiments. These groups are not responsible for spoilage in properly processed cans or jars, and may therefore be disregarded for the present purposes. The powder in the amount recommended for canning had no inhibitory effect on representative members of the anaerobic spore-forming group, especially the toxin-forming *B. botulinus*, which has recently been responsible for many deaths from food poisoning.

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[9] Bigelow, W. D., and Cathcart, P. H. Relation of Processing to the Acidity of Canned Foods. National Canners' Assn. Research Laboratory Bull. 17–L (1921).

[10] Weiss, Harry. The Heat Resistance of Spores with Special Reference to the Spores of *B. botulinus*. J. Inf. Dis., 28 (1921) : 70–92.

In the practical canning experiments the use of the powder for acid products was shown to be an unnecessary and wasteful practice, since material packed without the powder kept as well as that packed with it. Its use with the more or less neutral vegetables showed that the powder plus the inadequate heating recommended was not sufficient to preserve the materials or to prevent the production of toxin in them by *B. botulinus*.

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